GEOCHEMISTRY

of the

ORDOVICIAN BOAS OIL SHALE,

SOUTHAMPTON ISLAND, NORTHWEST TERRITORIES

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Contract #01SG.23294-5-0629, Serial #0SG.85-00075

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Calgary, Alberta

Geological Survey of Canada
Open File Report OF1285

1986

TABLE OF CONTENTS

Page

Abstract.....1
Introduction.....1
Sample Inventory.....2
Stratigraphy.....4
Distribution.....5
Lithology.....8
Organic Petrology.....10
Geochemistry.....10
Analysis - Rock-Eval Data.....11
Pyrolyzate.....12
Economic Potential.....12
Summary.....14
References.....14

FIGURES

Figure 1: Sample localities with surface distribution of Boas oil shale beds as interpreted from Nelson and Johnson (1976).....3

2: Diagrammatic representation of mineralogy, Boas oil shale.....9

3: Inter-relationship of Hydrogen and Oxygen indices, Boas oil shale.....12

4: Relationship of petroleum potential (yield) to total organic carbon content, Boas oil shale.....13

TABLES

Table I: Relative mineral assemblages (%) in Southampton Island oil shale samples from X-ray diffraction analyses.....7

II: Reflectance and fluorescence data for Boas oil shale.....10

III: Geochemical data from Rock-Eval pyrolysis of Southampton Island oil shale samples.....11

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ABSTRACT

Fourteen samples, collected at three surface locations, were analyzed geochemically by Rock-Eval pyrolysis. X-ray diffraction was used to determine relative mineral compositions for all samples. Macerals were identified by reflected light microscopy and gas chomatography of the solvent extract fraction provided initial qualification of the petroleum products.

The Boas oil shales are immature Type II marine sapropelic (amorphous) limestones, wherein the organic matter is almost entirely matrix bituminite. Hydrogen and Oxygen indices average 565 and 65 respectively: yield ratios approximate 5.8 kg/tonne/%TOC. The yield ratios are slightly lower for TOC content below 5%. Low maturation levels are confirmed by gas chromatography of the solvent extract saturate fractions.

Optimum yields in excess of 80 kg/tonne, and up to 134 kg/tonne, can be obtained from an uppermost laminated unit, approximately 25 cm thick, within which TOC ranges from 10 to 20%. Yields are generally below 40 kg/tonne in the lower part of the oil shale interval where non-organic limestones interbed with poorer quality oil shales. There does not appear to be sufficient thickness of high yield strata to be economically attractive.

INTRODUCTION

Oil shales on Southampton Island were first reported by Nelson and Johnson (1966) wherein the best localities were defined at Sixteen Mile Brook and Gore Point: the oil shale zone was considered to be present northward to the Duke of York Bay area, and hydrocarbon recoveries were reported to range from 5 to 37 Imp. gallons/ton from a gross oil shale-bearing interval approximately 50 ft. (16m) in thickness, and possibly containing up to 50% oil shale beds. In 1976, Nelson and Johnson presented a much more comprehensive review of the deposits, providing preliminary Fischer Assay values from samples collected at 99 locations, and assayed with field equipment. Most of the samples were collected from float which was considered to be essentially in place.

Heywood and Sanford (1976) reported a third excellent location, on the Boas River, where 6 to 7 feet (2m) of oil shale beds were informally defined as the Boas River oil shale. Heywood and Sanford were unable to locate the principal oil shale areas of Nelson and Johnson, but considered their oil shale zone to be older than that of Nelson and Johnson. Nelson (1981) reviewed the stratigraphy and concluded that the three major areas contained stratigraphically equivalent oil shale beds. In essence, there has been considerable conjecture on whether there is only one, or possibly two, main oil shale interval(s) on Southampton Island.

Macauley (1984) outlined this and the related problem, whether the oil shales occur at the Middle-Upper Ordovician boundary, the Upper Ordovician-Silurian boundary, or within the Upper Ordovician and/or Lower Silurian sequences.

As part of the assessment of future potential Canadian oil reserves from unconventional sources, the Geological Survey of Canada first compiled available data for Canadian oil shales and presented those data in a comprehensive review paper (Macauley, 1984, G.S.C. Paper 81-25). The more southerly and obviously more economically attractive deposits were then studied by geochemical techniques, both independently by the G.S.C. and also in conjunction with the Provinces, with results published in G.S.C. Paper 85-13 (Macauley et al, 1985). Because of local potential for utilization in an energy-deficient area, the oil shales of Southampton Island were also considered of sufficient interest to warrant geochemical analyses comparable to those of other oil shale areas. After a detailed review of the literature, and after personal consultations with both Nelson and Johnson concerning their prior efforts, a decision was made to sample the three optimum areas of oil shale exposures at Sixteen Mile Brook, Gore Point and on Boas River (Fig. 1). These ares were sampled by the author, in cooperation with N.J. McMillan of the Geological Survey of Canada, Calgary, in August of 1985. The samples were subsequently analyzed by Rock-Eval pyrolysis at I.S.P.G., Calgary, and also subjected to XRD mineralogical determinations. Also at the I.S.P.G., F. Goodarzi conducted preliminary organic petrology studies, including maceral identifications and fluorescence investigations.

During the course of the field sampling, no attempts were made to collect fossils or lithologic samples beyond those required for the geochemical and petrological studies; however, sufficient sample was available from the Sixteen Mile Brook and Boas River sections to enable conodont determinations to be carried out at I.S.P.G. by A. Higgins: results of the conodont studies are not yet available. Although no efforts were directed toward solution of the stratigraphic position of the oil shale zone(s), the inter-relationship of the oil shale beds to the overlying and underlying strata was observed sufficiently that some inferred conclusions are presented herein.

Sample Inventory

Five samples were collected at the Sixteen Mile Brook location, from the same outcropping described and sampled by Nelson and Johnson (1976) as sample no. 50.

SMB_1: float collected from within the top metre of section on a dry creek bed just west of the main outcrop section; lithology is semi-laminated to somewhat papery but not so laminated as sample no. 3 at this location.

SMB_2: outcrop in the same dry stream bed as sample no. 1 above, at a small bend a few metres upstream of the float collection; slightly lower stratigraphically than sample 1; brownish oil shale interbedded with light yellowish-brown light grey weathering limestone; beds approximately 1 cm thick.

SMB_3,_4,_5: Outcrop on the south side of Sixteen Mile Brook

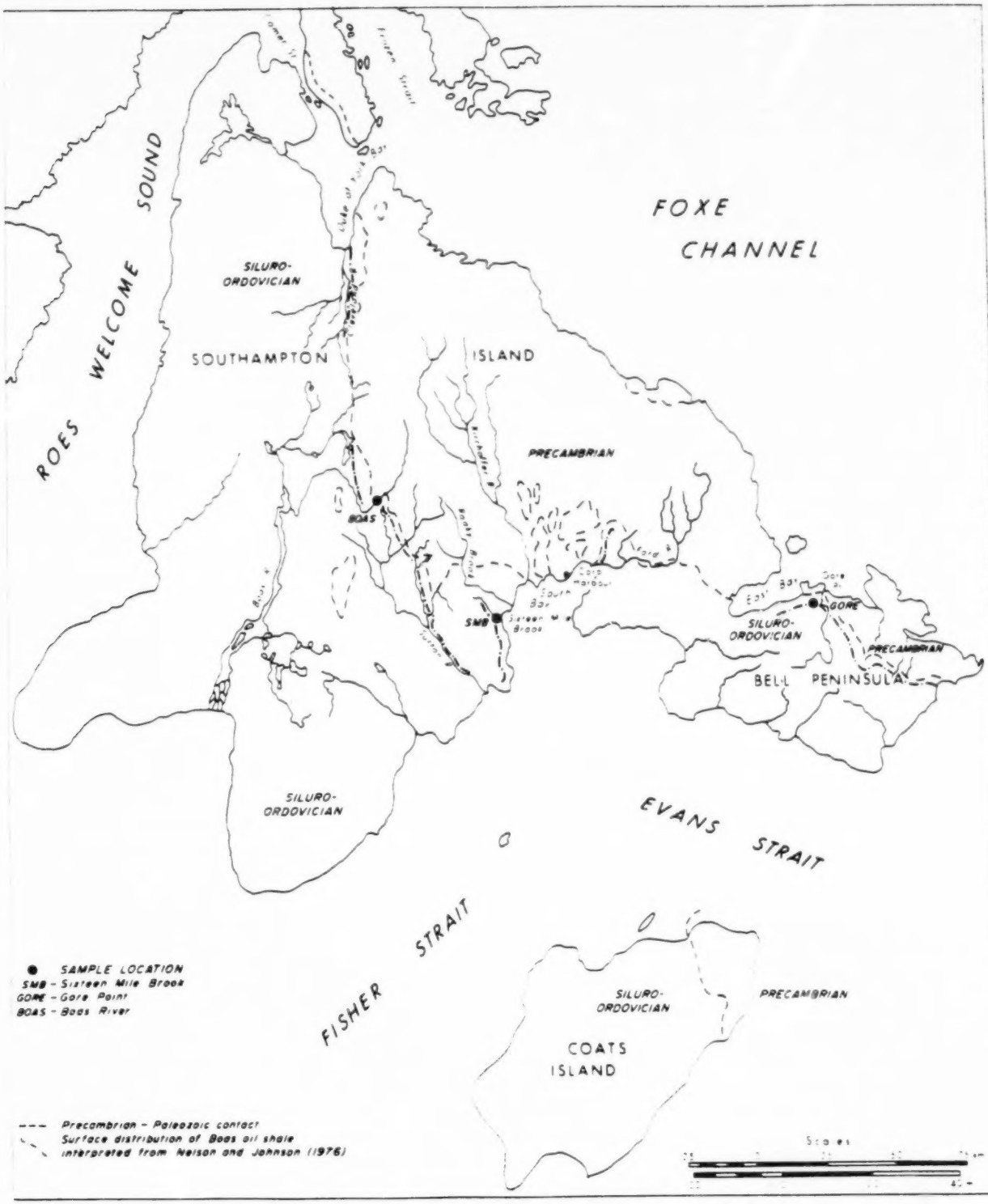

Figure 1: *Sample localities with surface distribution of Boas oil shale beds as interpreted from Nelson and Johnson (1976).*

approximately 800 m from the mouth of the brook; samples from an approximate 0.3m band at the top of the oil shale-bearing interval; no. 3 is from a papery-laminated, 2 to 5 cm thick uppermost band; no. 4 is from a more massive dark brown 20 cm band; no. 5 is from is from a thin zone transitional downward to the underlying lighter colored, yellowish tinted limestone.

Five samples were also collected at Gore Point in the vicinity of Nelson and Johnson (1976) samples 79 through 90.
Gore_1 is located at the base of the apex of a high grey-weathering carbonate plateau in which remnant biohermal masses are preserved; the oil shale is papery-laminated at the apparent top of the oil shale interval; only limited sample material is available as this oil shale type appears to be present as only a very thin bed.
Gore_2 is a grab sample from the scree west of the northern peak of the ridge and represents beds below the laminae of sample no. 1.
Gore_3,_4,_5: these samples were collected east of the ridge apex and again represent section below the uppermost papery beds; no.3 is the darkest brown; no. 4 is essentially light and dark color banded; no. 5 is the lightest colored, becoming greyer and in part with a yellowish tinge grading down to the underlying light yellowish brown limestone.

Four samples were taken at the Boas River.
Boas_1: this sample is from the bend in the Boas River where Nelson and Johnson (1976) collected their sample no. 19; approximately 1m at most of bedded (1cm) oil shale overlies an apparent thin zone of light yellowish brown to orange-brown limestone; underlying Precambrian is obviously very close below these beds from float distribution.
Boas_2,_3,_4: selected across the river and slightly upstream at what appears to be Heywood and Sanford's type section; sample no. 2 was taken above a possible fossil soil band to determine if the oil shale had there been altered from that below the dark zone; no. 3 is from thicker beds, up to 1.5 cm, generally near the top of the exposed oil shale interval; the lowest sample no. 4 is from a zone of interbedded light and dark oil shale and limestone near the base of the oil shale unit and is transitional downward to the underlying yellowish brown limestone.

STRATIGRAPHY

Nelson and Johnson (1966, 1976) divided the Ordovician carbonates of Southampton Island into two units, a lower Bad Cache Rapids Group and an upper Churchill River Group based on both lithologic and paleontological correlations with the established type sections of the Hudson Bay Lowland (Nelson, 1963, 1964). Within this sequence, the oil shales were placed in the uppermost Churchill River Group, essentially at the Ordovician-Silurian boundary. The stratigraphic position was best defined by their sections at Sixteen Mile Brook and Gore Point as well as by the distributional pattern of the oil shale float

occurences relative to the outcroppings of other units (Nelson, 1981).

Heywood and Sanford (1976) amended the stratigraphy, assigning strata just above, and possibly in part within, the Churchill River Group of Nelson and Johnson to the Red Head Rapids Formation of Ordovician age. Their Boas River oil shale was assigned to an interval near the Middle-Upper Ordovician time boundary. Heywood and Sanford also mapped the strata directly overlying the oil shales at Sixteen Mile Brook and Gore Point within different stratigraphic intervals, without recognizing the presence of the oil shale beds at either location. This, in effect, would require that these oil shale occurrences be separate stratigraphically. Nelson (1981) detailed the history, the lithologies, and the paleontology of this complex situation.

For assessment of the oil shale potential as a local hydrocarbon source, the exact stratigraphic position is not an overly important factor; however, the number of zones, whether one or more, is important to the distributional pattern of any potential hydrocarbon reserves. On a much broader basis, the stratigraphic position becomes much more significant. Heywood and Sanford (1976) equate the Boas River oil shale beds with the late Middle Ordovician Collingwood oil shales of southwestern Ontario. These latter shales are important both as oil shales for present exploitation (Macauley, 1985) and also as the source for some of the conventional hydrocarbon reserves of that area (Powell, et al, 1984). Similar beds have not been reported from the Hudson Bay Lowland (Nelson, 1964; Nelson and Johnson, 1966; Sanford et al, 1968; Norris and Sanford, 1973; Cumming, 1975). Nelson and Johnson (1968) suggested that a thin, grey, apparently inorganic shale zone in the Sogepet-Aquitaine-Kaskattama Province No. 1 well, located on the west shore of the central Hudson Bay Lowland, may be the stratigraphic equivalent of the oil shales of Southampton Island. Heywood and Sanford (1976) have also indicated the presence of Ordovician oil shales on Aptopak Island in Ungava Bay. Correlations become significant to assist definition of initial areal distribution of these beds as prime source rocks for conventional petroleum in Hudson Bay and in other offshore areas adjacent to these surface exposures.

DISTRIBUTION

Good outcrop sections are virtually unknown for the oil shale beds of Southampton Island: from the descriptions of the previous investigators, good outcrop sections are known for only limited parts of the Paleozoic (Siluro-Ordovician) section.

At Sixteen Mile Brook (Fig. 1), an excellent section is exposed, wherein the oil shale beds are overlain by grey-weathering dolostones, and underlain by yellowish brown limestone. The oil shale interval comprises an uppermost, thin, five to eight cm thick bed of finely laminated dark brownish black oil shale that ignites readily, overlying approximately 20 cm of dark brownish black, more massively bedded (2 to 4 cm) oil shale. These in turn grade downward to medium brown, 2 to 4 cm

thick beds of poor quality oil shale, which does not ignite but which exudes a petroliferous odor on breaking and which will smoke in a flame. An underlying section of approximately 4m consists of some interbeds of the above medium brown oil shale within a section of yellowish brown limestone. The oil shale occurrences appear to have been exposed fully at the base of this section, although Nelson and Johnson, (1976) encountered oil shale float at the mouth of the brook and considered that some 50 feet (16-17m) of oil shale-bearing interval was present.

The section at Gore Point is less specific as the oil shales are there recognized only from erosional debris. Nelson and Johnson (1976) inferred that the debris was virtually in situ, and this conclusion appears to be valid. A thin band containing rubble of finely laminated, dark brownish black, ignitable oil shale was traced around the base of a significant beach-derived plateau of grey-weathering carbonate identical in character to that overlying the similar oil shale bed at Sixteen Mile Brook. Below the laminated beds at Gore Point, the rubble consists dominantly of somewhat more massive, medium brown oil shale over two low beach ridges, each about 2m high. These apparently intergrade with yellowish brown limestone in the lower interval, essentially identical to the section exposed on Sixteen Mile Brook. There is only minimal apparent southward dip of the beds in this area; consequently, the total oil shale zone is not considered to exceed 4m. Nelson and Johnson (1976) had here also estimated as much as 16 to 17 m of gross oil shale-bearing interval. Precambrian rocks are exposed nearby to the north and northeast, sufficiently close that the thickness of the inorganic limestones underlying the oil shales can be a few metres at most.

The total lithologic sections, from the overlying beds through the oil shale interval to the underlying inorganic limestones, are so similar at Sixteen Mile Brook and Gore Point that the two sections must be considered as stratigraphically equivalent.

At the Boas River section, well described by Heywood and Sanford (1976), slightly over 2m of medium brown oil shale beds overlie yellowish brown limestone, identical in character to those described below the oil shale beds at the other two areas sampled. At Boas River, the underlying limestones appear to be less than 2m in thickness, as stream beds entering the river across from the oil shale outcrop variably contain limestone or Precambrian rock float. In this aspect, the Boas River section much resembles that at Gore Point. A thin dark zone, which has the characteristics of an ancient soil, overlies the oil shale beds along an apparent bedding plane of the oil shale interval, and is in turn overlain by a possible rubble sediment containing fragments of apparently unaltered oil shale beds similar to those below the possible fossil soil. This upper unit, about 1m thick, is overlain by alluvium. There is no evidence of the uppermost, blacker, papery-laminated oil shale lithology which appears to have been removed below the fossil soil lens.

Lithology of the oil shale beds at Boas is identical to the lower section encountered at the two other locations, as is that

of the underlying limestone. There is no nearby indication of the nature of the overlying beds at Boas River, but the excellent lithologic correlations of the oil shales and of the underlying limestones indicate strongly that only one oil shale zone is present, as concluded by Nelson (1981). Considerable additional paleontological evidence will be required, and core drilling may be necessary to provide more definitive lithologic sections before the exact stratigraphic position of these beds can be resolved. The general distribution of oil shale beds, as outlined by Nelson and Johnson (1976) and again by Nelson (1981) from few outcrops and from float occurrences, and as shown herein (Fig. 1), must be considered to be as accurate as can probably be mapped when the present terrain of Southampton Island is understood.

Two distributional features are noteworthy. There are no apparent oil shale beds around inliers of Precambrian beds south and west from the Boas River section (Fig. 1), and oil shales are also missing from the equivalent Lower Paleozoic section on nearby Coats Island (Nelson and Johnson, 1976). Heywood and Sanford (1976) also failed to find any oil shale beds in these two areas. Two explanations are possible. The beds may be missing by facies change or erosion below the overlying grey carbonates, or the oil shales may be missing by non-deposition against Precambrian topographic highs. This would necessitate that a considerable part of the Ordovician section, as mapped by Heywood and Sanford, is actually younger than they indicate: this would appear to be the interpretation preferred by Nelson (1981). Much more study is obviously required to resolve this question of distribution.

Although the distribution of the oil shale strata does follow closely the Precambrain-Paleozoic contact, there are several anomalies to this condition. Along the southern reaches of the Cleveland River (Fig. 1), these beds are missing by non-deposition against the Precambrian as is illustrated by both Nelson and Johnson (1976) and Heywood and Sanford (1976). Nelson and Johnson (1976) mapped oil shales along the edge of the Paleozoic subcrop belt northeasterly of Coral Harbour, but not within any of the small outliers in the triangle between the Kirchoffer and Ford Rivers. Oil shale beds may be absent from this area by erosion as only the lowermost Ordovician strata appear to be present.

The Sixteen Mile Brook section is somewhat removed from the Precambrian-Paleozoic contact, but is located in an area of thinner sediments which trends northwesterly between Sixteen Mile Brook and Sutton River. Erosion in the channels has been sufficiently deep in the section to expose the oil shale beds.

Nelson (1981) suggested that, if two zones are present, they could be named the Boas River shale and the Sixteen Mile Brook shale. Because of the pronounced lithologic correlations that are evident, and the prior use of Boas River, the unit will here be informally defined as the Boas oil shale. In accordance with past desires of the AAPG Stratigraphic Nomenclature Committee to avoid double names, "River" will not be included in the name.

LITHOLOGY

Previous writers have described the oil shale lithologies only briefly. The shales were generally described as black to dark brown, with the higher-oil-content shales being slightly calcareous and fissile, whereas the leaner shales are moderately calcareous and non-fissile.

A more precise lithologic description can now be provided with the assistance of X-ray diffraction analyses. Semi-quantitative results of the whole rock were obtained from the diffraction peak heights which may vary with degrees of crystallinity, crystal size and any amorphous material present. The data obtained (Table I) represent relative approximate concentrations and are not absolute values.

For the analyses, one portion of powdered sample was pelletized on a cellulose substrate and X-rayed with Cobalt K-alpha radiation, iron filter, settings of 40 Kv-20 ma with chart speed at 2cm/min., 1°/2cm. A second analysis was made with Copper K-alpha radiation, nickel filter, and the same settings and chart speed.

Sample	Illite	Kaol/ Chlor	Quartz	Feld	Calcite	Dol/ Ank	Py	Other
SMB 1	1	1	26	tr	70	2	tr	mlc-tr
SMB 2	tr	tr	36	-	50	14	tr	-
SMB 3	2	5	36	tr	54	-	tr	mlc-tr Anatase?-tr
SMB 4	1	2	24	-	72	-	1	-
SMB 5	-	-	3	-	97	-	-	-
Gore 1	2	2	26	-	69	-	1	gyp-tr
Gore 2	1	tr	28	-	64	7	tr	-
Gore 3	tr	tr	30	-	65	5	-	-
Gore 4	tr	tr	26	-	61	13	tr	-
Gore 5	tr	tr	34	-	56	10	tr	-
Boas 1	1	1	21	1	73	3	tr	-
Boas 2	tr	tr	25	-	70	5	tr	-
Boas 3	tr	tr	29	-	56	14	1	-
Boas 4	tr	tr	26	-	64	9	1	-

Kaol-kaolinite; chlor-chlorite; feld-feldspar; py-pyrite; dol-dolomite; ank-ankerite; mlc-mixed layer clay; tr-trace

TABLE I: Relative mineral assemblages (%) in Southampton Island oil shale samples from X-ray diffraction analyses.

Based on the mineralogical data, the oil shales are all limestones, which are microgranular and in which the quartz must also be of micro size as silt and sand size grains are not detected under macro observation. Whether the significant quartz content occurs as an extremely fine detritus or as a precipitate within the limestone has not been examined. Terrestrial detritus

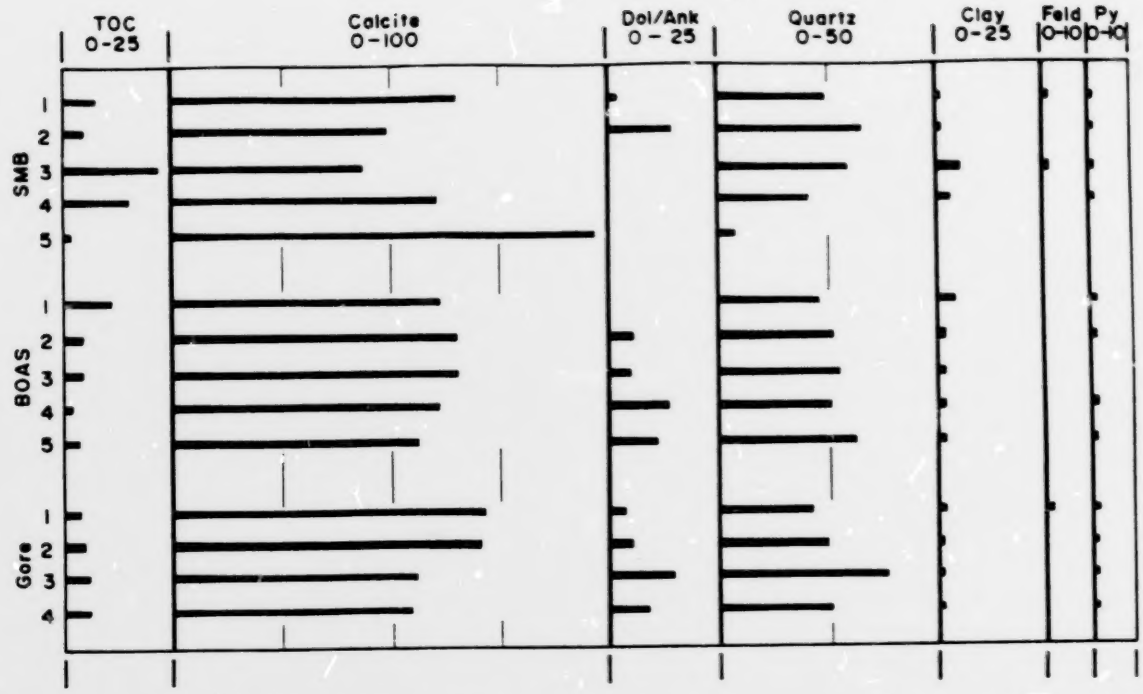

Figure 2: *Diagrammatic representation of mineralogy, Boas oil shale.*

is minimal as noted by the virtual absence of clay minerals and feldspar. The minimal content of clays and feldspar may be an indicator that the quartz is chemically derived rather than detrital.

Although reported together, variable dolomite-ankerite content probably constitutes mostly dolomite, and irregular dolomitization of the limestones can be expected as overlying strata are dominantly dolomite. Color mottling is reported for many of the yellowish brown limestone beds, a characteristic commonly associated with the dolomitization process.

Although pyrite was detected in trace amounts in most of the samples, the amount of pyrite present must be considered negligible within a depositional environment capable of preservation of large amounts of kerogen.

Figure 2 is a plot of the mineral content, with percentages modified to compensate for the TOC component, which graphically illustrates the similarities of the oil shale beds at the three sampled locations. Where TOC content is high, the carbonate component is commensurately reduced.

In extremely fine micro-grained rocks, kerogen is comonly present as matrix bituminite, whereby the inorganic mineral grains are surrounded by the kerogen and protected from HCl acid

reaction tests. The apparent lower calcite content indicated by Nelson and Johnson (1976) for the higher yield beds can be attributed to this latter phenomenon. The carbonate content is essentially uniform within the total inorganic component throughout the oil shale beds at the three areas sampled.

The limestone character of these beds, with the minimal content of terrigenous detritus, detracts from any significance that might be attached to the suggested stratigraphic equivalence with the thin inorganic argillaceous shale zone in the Kaskattama well as suggested by Nelson and Johnson (1968).

ORGANIC PETROLOGY

F. Goodarzi (pers. comm., 1986) examined three samples of Boas oil shale representing high, medium and low yield beds as determined by the Rock-Eval pyrolyses. In the high and medium yield samples, the organic matter is almost entirely a matrix bituminite with negative alteration: only very little liptinite is preserved. Some rounded, grey, non-granular, non-fluorescing bodies, possibly a Type III kerogen, have low reflectance values (Table II). Only carbonate-stained bitumen was recognized in the low yield sample. Fluorescence values (Table II) are indicative of thermal immaturity.

TOC	Reflectance, Ro (%)				Fluorescence	
	Bitumen		Type III kerogen (Granular)		max	Red/Green Quotient
Low	.16	.23	.37	.43	--	--
Med	-	.24	-	.48	500	.59
High	.15	-	.33	-	477*	.53*
					460**	.29**

* bitumen ** algae

Table II: Reflectance and fluorescence data for Boas oil shale.

GEOCHEMISTRY

A standard program used for the Rock-Eval pyrolysis has been described in detail in Macauley et al (1985). The Rock-Eval pyrolysis apparatus at ISPG, Calgary, does not respond linearly to the S2 peak: the compensating techniques to overcome this factor are described in detail in Snowdon (1984) and briefly in Macauley et al (1985). Organic carbon content (TOC) was determined by the carbon analyzer component of the Rock-Eval analyzer. Table II presents the results of these analyses: for several of the samples, two analyses are provided. The interpretation of Rock-Eval data has also been outlined in considerable detail in Macauley et al (1985) and will not be included herein.

Sample	TOC %	Tmax °C	S1	S2	S3	HI	OI	S1+S2 kg/t	PI	Ratio kg/t /%TOC
				mg/g						
SMB 1	7.37	429	1.08	38.71	6.73	525	91	39.79	.03	5.39
SMB 2	3.32	424	.88	20.61	1.23	620	37	21.49	.04	6.47
SMB 3	20.31	424	6.00	113.30	6.08	557	29	119.30	.05	5.87
3	22.57	421	7.79	127.15	8.62	563	38	134.94	.06	5.97
SMB 4	14.78	423	4.60	93.40	4.90	631	33	98.00	.05	6.63
SMB 5		427	.43	8.69	1.43			9.12	.05	
Gore 1	11.74	426	2.50	80.15	7.81	682	66	82.65	.03	7.04
1	9.66	423	3.76	63.11	6.66	653	68	66.87	.06	6.92
Gore 2	3.46	432	0.70	19.36	3.23	559	93	20.06	.03	5.79
Gore 3	3.81	427	.49	18.63	3.72	488	97	19.12	.03	5.01
Gore 4	1.86	428	.37	9.92	1.11	533	59	10.29	.04	5.53
Gore 5	2.35	424	.40	11.90	1.29	506	54	12.30	.03	5.23
5	3.36	424	.39	20.05	1.84	596	54	20.44	.02	6.08
Boas 1	2.73	424	.55	16.64	1.25	602	45	17.19	.03	6.22
1	3.62	427	.68	16.81	4.39	464	121	17.49	.04	4.83
Boas 2	4.43	428	.67	25.06	2.37	565	53	25.73	.03	5.80
Boas 3	5.78	425	.48	30.40	4.19	525	72	30.88	.02	5.34
Boas 4	6.25	427	.51	33.01	5.77	528	92	33.52	.02	5.36

Table III: Geochemical data from Rock-Eval pyrolysis of Southampton Island oil shale samples.

Analysis: Rock-Eval Data

Tmax: All Tmax values are less than the 435°C normally assigned as the onset temperature for petroleum generation, ranging for the Boas oil shales from 423 to 432°C. Thermal immaturity must be interpreted from these data. This is confirmed by the Production Index (PI), the ratio S1/(S1+S2), which, in the range 0.02 to 0.06, indicates the virtual absence of generated hydrocarbons.

Hydrogen-Oxygen indices: Hydrogen Indices range from a low of 464 to a highest value of 682, but most are in the "500" range, which is characteristic of Type II kerogen (Fig. 3). The Oxygen Indices, ranging from 29 to 121, averaging near 65, are indicative also of Type II kerogen.

Yield ratio: The ratio of yield to total organic content, the total of the S1 and S2 peaks divided by the percentage of total organic carbon, varies from a minimum 4.83 to a maximum 7.02 with an average ratio approximating 5.9 (Fig. 4), well below the >8 ratios of Type I lamosites (Macauley and Ball, 1982), but much higher than the lower ratios in the 3 to 4 range often associated with the Type II mixed deposits (Macauley et al, 1984). The yield ratio here is similar to that of the marginal to low thermal maturity Ordovician Collingwood oil shales of southern Ontario (Macauley and Snowdon, 1984). The yield ratios of the higher organic carbon samples are seen to be slightly better than anticipated from the arithmetic mean (Fig. 4).

Classification and maturation: The Boas oil shales are thermally immature, Type II, marine sapropelic oil shales under the classification and maturation system proposed by Macauley et al. (1985, p. 2-4, Fig.2) for Canadian oil shale deposits.

These beds were deposited as a thin sheet following a period of carbonate deposition, similar in character to the Collingwood deposit. The Boas shales are overlain directly by carbonate whereas the Collingwood interval was followed by non-organic shale deposition. Such deposits are normally areally widespread; however, a possible limited distribution of Collingwood beds has been outlined (Macauley et al, 1985). The limited areal extent of the Collingwood may be attributable either to non-deposition or to erosion: a similar interpretive problem can be visualized regarding distribution of the Boas beds.

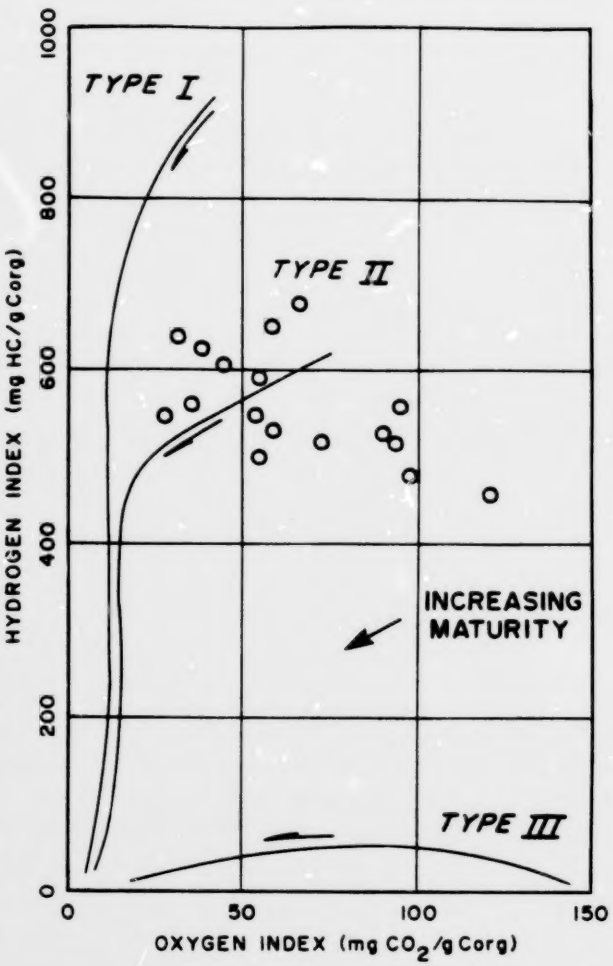

Figure 3: *Inter-relationship of Hydrogen and Oxygen Indices, Boas oil shale.*

Pyrolyzate

Gas-chromatogram traces were prepared by L. R. Snowdon at the ISPG for a solvent extract saturate fraction from one of the high yield samples. The pristane/phytane ratio is low at 0.73, but there is a slight odd/even predominance. Pristane/nC_{17} (1.81) and phytane/nC_{18} (3.12) along with a high concentration of sterane and terpane biomarkers indicate thermal immaturity. Alkylbenzenes are noted in the gas chromatogram of the aromatic fraction.

Pyrolysis-gc results from the whole rock and asphaltene fraction are peculiar. The S1 and S2 peaks of the whole rock are not clearly identifiable and the S1 peak of the asphaltenes should theoretically be blank, but is not.

Economic Potential

The uppermost beds, estimated to be less than 30 cm thick, can contain in excess of 20% TOC, and have generally recorded in excess of 10% TOC (Table II, samples SMB 3, SMB 4, Gore 1). At

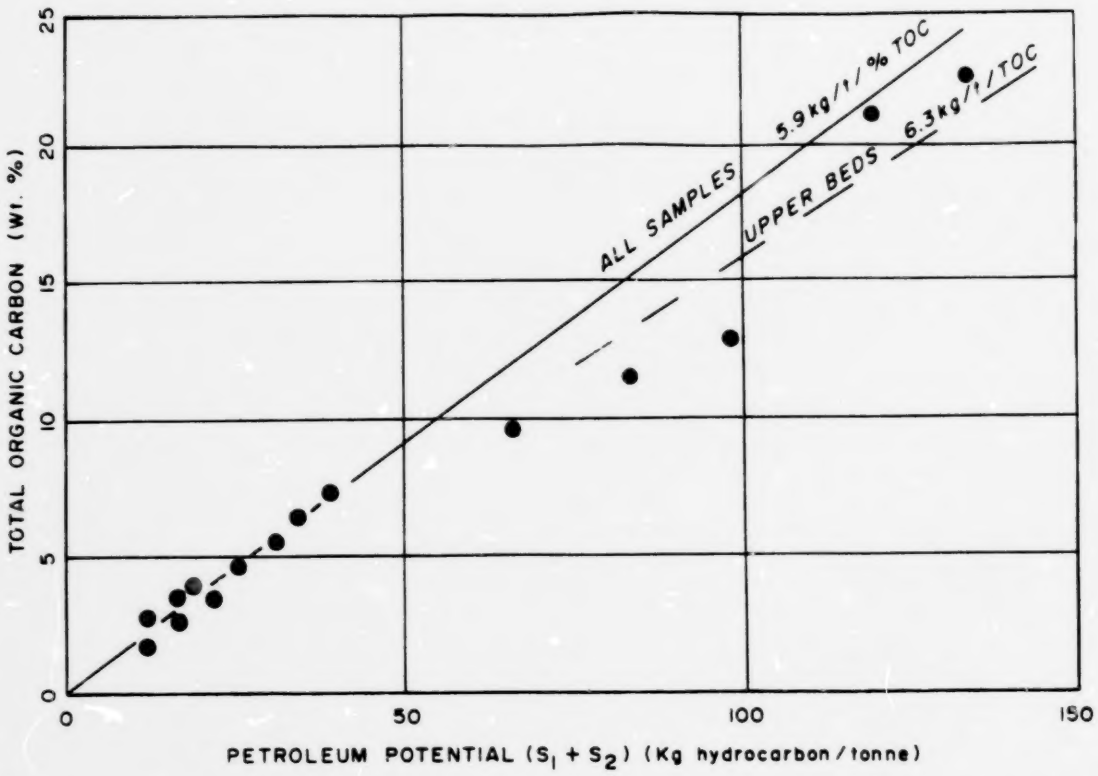

Figure 4: *Relationship of petroleum potential (yield) to total organic carbon, Boas oil shale.*

the Sixteen Mile Brook section, the highest TOC contents are from the ignitable, thin, finely laminated, papery zone at the top of the unit. Total hydrocarbon yields from these beds range from 82 to 135 kilograms/tonne (kg/t). Specific analytical data are not available by which these results can be converted directly to US gallon/ton (g/t) measurements: in comparison to known data from the Collingwood oil shales of Ontario, a specific gravity of 0.94 can be assumed to make the required conversion. These recoveries are excellent, in the range of 21 to 34.5 US g/t. Nelson and Johnson (1976), using field-type Fischer Assay equipment, reported slightly higher recoveries of 33 Imp g/t for these beds. The values from the two techniques are sufficiently close that Nelson and Johnson's field results can be considered reliable.

Although some 3 to 4 m of oil shale or oil shale-bearing interval is present below the high yield beds, these underlying strata are of much more limited potential as TOC ranges 2 to 7%, with consequent hydrocarbon yields on pyrolysis of 10 to 40 kg/t (2.5 to 10 US g/t), generally below any levels considered to be economically attractive at the present time.

The Boas oil shales, although containing an excellent upper interval, do not have sufficient thickness of high yield beds to be of economic interest for oil shale development, even on a local scale; however, if present and buried to sufficient depth to effect thermal maturation, the Boas zone represents an excellent potential source of hydrocarbons for the offshore Hudson Bay Basin. In this aspect, the definition of

stratigraphic position and areal distribution becomes most significant for offshore exploration potential.

SUMMARY

Boas oil shales are thermally immature Type II marine sapropelic deposits which occur as an upper unit, approximately 25 cm thick, of dark brownish black papery-laminated to thin bedded, high yield (TOC >20%) beds and as a lower unit, possibly 2 to 3 m thick, of light to medium brown low yield (TOC 2 to 7%) beds approximately 1.0 to 1.5 cm thick.

The oil shales are limestones, with minimal clay and feldspar content, but with a significant (up to 30%) quartz content which is of undefined detrital or chemical precipitate origin.

Thickness of the high yield oil shale beds is insufficient to consider the zone as economically potential; however, the Boas oil shale, if present and having been buried to sufficient depth to effect thermal maturation within the oil-producing window, is an excellent potential source for hydrocarbons in the offshore Hudson Bay Basin.

Because of the source potential of these beds, further investigations to define the stratigraphic position and areal distribution must be an important objective for future geological investigations on Southampton Island, and for correlations both within the Hudson Bay Basin and to the Hudson Bay Lowland to the south.

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